PATENT SPECIFICATION

617,224

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Index at acceptance:—Classes 7(iii), B2j(2: 5); and 122(i), B(3e: 7d1).

PROVISIONAL SPECIFICATION

Improvements in or relating to Pistons

We, HARRY RALPH RICARDO, British Subject, of 21, Suffolk Street, Pall Mall, London, S.W.1, and GEORGE ALLEN HOLT, British Subject, and RICHARD WATTS, British Subject, both of Bridge Works, Shoreham-by-Sea, Sussex, do hereby declare the nature of this invention to be as follows:—

This invention relates to pistons and more particularly to the cooling of trunk pistons by lubricating oil delivered into the interior of the piston from the end of the connecting rod to which it has been conveyed through suitable passage ways the delivery being preferably timed by the arrangement and disposition of passages in the big-end bearing and crank pin.

In a known method of cooling the pistons of internal combustion engines oil conveyed up the connecting rod from the big-end is delivered in the form of one or more jets against the underside of the piston crown and in some cases also against that part of the wall or skirt of the piston which lies behind the rings. The oil is then drained from the piston by inertia forces.

The object of the present invention is to provide a piston in which the oil supplied thereto will be used to better advantage in cooling those parts of the piston where the rings are carried and which lie adjacent to the piston crown.

According to this invention a trunk piston has formed in it an annular chamber which is bounded outwardly by the wall or skirt of the piston and in one axial direction by the crown of the piston and in the opposite direction by an annular formation which projects inwardly, the chamber having an annular opening leading radially into it and through which can pass oil delivered in jets from the end of the connecting rod, the oil in the chamber being shaken in the axial direction between the crown and the said annular projection as the piston reciprocates thereby having a cooling effect especially on the wall behind the rings. The construction comprises in combination an annular part projecting inwardly from the skirt of the piston, a recess or trough in this part with its hollow facing the crown of the piston and forming an annular chamber with an annular opening leading into it from the direction of the piston axis, and means for delivering oil in one or more jets from the end of the connecting rod into the interior of the piston and so into the said annular chamber through the opening leading into it, the formation of the chamber being such that some portion of this oil will be retained therein and shaken between the trough and the piston crown as the piston reciprocates. In this way the oil delivered up the connecting rod to the piston becomes trapped in the annular chamber and in the trough or recess therein and will be shaken by inertia forces towards and away from the crown passing over the wall and thus having a cooling effect on these parts before the oil escapes from the chamber and returns to the crank case.

The internal structure of the piston which provides the annular chamber in which the oil will be shaken in the manner indicated may vary, but the following are instances by way of example as alternate forms which may be employed.

In each case there is provided what is in effect an inwardly directed flange-like member which projects towards the piston axis from the wall or skirt, being situated near the gudgeon pin bearing and on the crown side thereof with that part of the wall of the piston in the exterior of which are carried the rings lying between the annular flange and the crown. At the inner edge of this flange is an upturned lip directed towards the crown and forming between it and the wall of the piston a recess or trough which may be continuous as a completely annular trough or divided into two seg-

mental parts lying respectively on each side of and extending in the circumferential direction between the gudgeon pin bosses. The annular space between the crown and the flange and within the lip of the latter constitutes an annular chamber on the inner side of that part of the wall or skirt in the outer part of which are the grooves containing the rings, the opening into this chamber being between the crown and edge of the lip. Through this opening will pass oil delivered in jets from the end of the connecting rod and as the oil will be trapped in the chamber from which it cannot readily escape otherwise than over the lip or by way of one or more small drain passages, it will be shaken to and fro between the crown and the flange being in this way caused to flow at least in some part over the surface of the wall behind the grooves containing the rings with a cooling effect.

The lip around the inner edge of the inwardly directed flange in the piston may be substantially cylindrical or it may be inclined so as to have a somewhat conical form and its depth, that is its measurement in the axial direction, may vary.

The lip may be formed integral with the inwardly directed flange which itself is integral with the wall or skirt of the piston but in some cases and more particularly if the piston is formed by casting, the lip may be constituted by a separately constructed piece which is suitably connected to the inwardly directed flange. Such an inserted piece for example may have a tubular formation with an external radially directed flange adapted to lie against the inwardly directed flange of the piston and these flanges may then be connected by studs. The tubular insertion is conveniently oval in cross-section but in some cases it may be circular and when so formed it may be connected to the flange within the piston by screwthreading the exterior of the insertion and the edge of the piston flange. In such a case the inserted piece may have an external rib which will determine its position in the axial direction when screwed into the piston flange. The length of the tubular insertion in the axial direction may vary in accordance with other details in the construction.

In some cases the crown of the piston may be formed on its under side with an annular projection extending for a suitable depth in the axial direction towards the edge of the lip around the flange which as mentioned projects inwards from the wall of the piston. This projection from the crown will then form an annular trough or recess in the marginal part of the under side of the crown behind at least one or more of the rings and facing the recess or recesses in what may be regarded as the opposite end of the annular chamber. The oil delivered into this chamber will then be shaken between the opposed troughs and thus at least mainly kept in the chamber and caused to move over the inner surface of the skirt and have the desired cooling effect. In place of an annular projection from the inner face of the piston crown which may be otherwise flat, the outer face of the crown may be recessed as in certain known forms of piston when the centre portion of the crown as a whole has a somewhat cup-shape and projects inwardly, the annular trough for the oil then lying around this central part.

The lip which projects from the internal flange towards the crown as also the annular projection which as described above may extend from the face of the crown towards the lip, may both merge into flanges on a supporting rib connecting the gudgeon pin bosses with the crown of the piston in a known construction.

Some the oil which is trapped in the annular chamber may flow away by passages leading from the bottom of the annular trough to the gudgeon pin bosses, the inertia forces acting on the oil in the annular chamber tending to force some of this oil to flow to the gudgeon pin. The bulk of oil will ultimately find its way out of the trough over the lip and so flow down towards the crankcase. In order to prevent oil passing over the lip from flooding the oil drain passages from the scraper ring towards the end of the piston skirt, the inwardly directed flange which carries the lip may be provided with a skirt directed oppositely to the lip and spaced inwardly from the piston skirt and between it and the end of the connecting rod. This skirt dependent from the flange will assist the oil escaping from the annular chamber over the lip to flow down the outside of the connecting rod to the crankcase. Where the lip is constituted by a separately formed and inserted tubular piece attached to the inwardly directed piston flange as above described this inserted piece may be of such length in the axial direction that in addition to a part thereof projecting towards the crown and constituting the lip around the edge of the piston flange there will be an extension in the opposite direction, that is towards the gudgeon pin, which will constitute a skirt as above mentioned

to assist the oil coming from the annular chamber and over the lip to flow down the outside of the connecting rod. With an inserted piece thus extending in both directions from the piston flange it is more particularly desirable that the insertion should have an oval form in cross-section.

In some cases the inner surface of the piston crown may be curved so that the jets of oil delivered against the crown will be diverted towards the sides of the piston and the oil will then flow into the trough in the lower part of the annular chamber and behind the lip. The curvature of the under surface of the crown may be similar all round from a centrally positioned cusp or this cusp may be located to one side of the piston axis when the formation of the crown will tend to direct more oil into one part of the annular chamber than to the opposite part. With such an arrangement additional cooling will be provided for the parts in contact with which the greater part of the oil is caused to flow, and this arrangement may be particularly suitable for a piston of a known form for use in an internal combustion engine this piston having a laterally positioned recess in the face of the crown into which the fuel is directed.

In some cases there may be provided in the annular chamber ribs projecting inwardly from the wall of the piston and extending from the crown to the trough behind the lip in what may be called the bottom of the chamber. These ribs will increase the heat dissipating area in contact with the oil as it is shaken to and fro in the chamber, the ribs also serving to stiffen the piston. These ribs do not extend completely across the chamber in the radial direction but only project a short distance from the wall of the piston and are arranged so that they do not interfere with the circumferential continuity of the lower part of the chamber. While this chamber may be continuous all round within the piston, in most cases the trough-like bottom of the chamber is divided into two parts, each part extending circumferentially between the gudgeon pin bosses.

In such a construction as described above the best use is made of a given quantity of oil supplied through the connecting rod. Any given portion of the oil projected by the oil jets into the annular chamber within the piston will be retained there long enough to pick up considerably more heat than can be picked up by a corresponding quantity of oil which as heretofore is merely projected as a jet against the under side of the piston crown and then allowed to flow away.

Dated this 21st day of August, 1946.

KILBURN & STRODE,
Agents for the Applicants.

COMPLETE SPECIFICATION

Improvements in or relating to Pistons

We, HARRY RALPH RICARDO, British Subject, of 21, Suffolk Street, Pall Mall, London, S.W.1, and GEORGE ALLEN HOLT, British Subject, and RICHARD WATTS, British Subject, both of Bridge Works, Shoreham-by-Sea, Sussex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to trunk pistons of the kind in which the cooling of the piston is assisted by lubricating oil delivered into the interior of the piston from the end of the connecting rod to which it has been conveyed through suitable passageways, the delivery being preferably timed by the arrangement and disposition of passages in the big end bearing and crank pin.

It has been proposed in such pistons to provide a substantially closed chamber between the piston crown and a transverse wall extending from the interior of the piston skirt into close proximity to the end of the connecting rod, the end of which is formed so as to restrict the escape of oil between the transverse wall and the connecting rod through the opening in this transverse wall through which the jet or jets pass. It has also been proposed to provide laterally extending walls on the end of the connecting rod which make a close working fit with curved surfaces on the interior of the skirt of the piston so as substantially to close in the oil chamber beneath the piston crown.

In a still further arrangement it has been proposed to provide on the upper end of the connecting rod a funnel-shaped nozzle projecting into close proximity to the underside of the piston crown so as to leave a very small clearance space between it and the crown

through which oil delivered to the interior of the funnel from the connecting rod can escape and in this construction an internal ridge forming a small annular channel has been provided on the inner surface of the piston skirt at a point displaced from the crown, in which channel oil collects so as to increase the cooling effect.

The object of the present invention is to provide an improved trunk piston of the general kind referred to in which improved cooling of the piston by oil can be achieved in a simple, convenient and effective manner without undue complication and in a manner which will provide satisfactory cooling for the piston and particularly for the part of the piston carrying the piston rings.

A trunk piston according to the present invention comprising a crown from which projects a skirt portion carrying the gudgeon pin bosses has a circumferentially extending trough formed within the piston at a point displaced from the crown and comprising a wall which extends inwards from the inner circumferential surface of the skirt portion and a lip portion which extends towards the crown from the inner edge of this wall and leaves between the crown and the lip a slot through which oil delivered in one or more jets from the connecting rod can enter the trough and through which surplus oil leaves the trough and escapes through the open end of the skirt and two or more walls extending in a generally axial direction between the crown and the trough so that the oil thrown back and forth between the crown and the trough due to the reciprocating movement of the piston not only washes over the inner surface of the skirt portion between the crown and the trough but also over the surfaces of the axially extending walls whereby these walls act not only to increase the mechanical strength of the piston but also to carry heat from the crown and to transfer it to the oil thrown back and forth between the trough and the crown.

Preferably the axially extending walls comprise or include two walls each extending from one of the gudgeon pin bosses to the crown of the piston so that they act as strengthening struts between the crown and the gudgeon pin bosses in addition to their function in carrying heat from the crown to the oil. Further such walls in conjunction with the gudgeon pin bosses may divide the trough into two circumferential sections, such sections having no connection with one another except through the slots by which the oil enters and leaves them. In such an arrangement there may be provided in addition to the axially extending walls from the gudgeon pin bosses to the piston crown and separating the trough into the two sections, a series of circumferentially spaced walls extending from the crown to the trough but only partially across the trough so as not to divide it completely into further separate circumferential sections, these further walls being for example in the form of ribs extending axially along the inner circumferential surface of the skirt portion from the crown to the trough.

In some cases the part of the trough which constitutes the lip may be formed separately from and secured to the wall constituting the base of the trough. Further, whether the lip is formed integral with or separately from the base of the trough a substantially cylindrical skirt-like projection may extend from the inner edge of the base of the trough towards the open end of the piston around the connecting rod. Further, the piston crown may be provided with an inwardly projecting part to provide an annular recess lying approximately opposite to the annular trough so that oil thrown upwards from the trough will tend to enter the annular recess and to be returned from it to the trough during the reciprocating of the piston.

The accompanying drawings illustrate by way of example alternative constructions that may be employed in carrying the invention into practice.

Figure 1 is a longitudinal sectional elevation of one construction of piston embodying the present invention;

Figure 2 is a transverse section on the broken line 2—2 in Figure 1 looking in the direction of the arrows:

Figure 3 is a longitudinal section on the line 3—3 in Figure 1, that is in the plane containing the axis of the piston and the axis of the gudgeon pin:

Figure 4 is a plan showing the face of the piston which is illustrated in Figure 1;

Figure 5 is a longitudinal sectional elevation of a modified construction of piston;

Figure 6 is a section on the line 6—6 in Figure 5 looking in the direction of the arrows;

Figure 7 is a longitudinal sectional elevation of yet another construction of piston embodying the invention:

Figure 8 is a section on the line 8—8 in Figure 7, that is in the plane containing the axis of the piston and normal to the axis of the gudgeon pin;

Figure 9 is a transverse section on the

line 9—9 in Figure 8 looking in the direction of the arrows;

Figure 10 is a part longitudinal sectional elevation showing a modification of the underside of the crown of the piston;

Figure 11 is a similar view showing another modification in the formation of the head or crown of the piston, and

Figure 12 is a part transverse section showing the cooling ribs or fins as in the construction shown in Figure 10.

Referring to the construction shown in Figures 1—4, the piston comprises a head or crown A and a skirt B and within the latter is an inwardly directed circumferentially extending wall C projecting towards the piston axis from the skirt, this flange-like member being situated near the gudgeon pin bosses D and between them and the crown of the piston. The position of the wall C is such that the part of the wall of the skirt B in which are the piston ring grooves B^1 lies between the wall C and the crown of the piston. At the inner edge of the wall C is an up-turned lip E directed towards the crown A and forming with the wall B, a trough F which is divided into two segmental sections by walls D^1 which extend between the gudgeon pin bosses D and the crown A of the piston and constitute struts between these parts. The two sections of the trough thus lie respectively on each side of, and extend in the circumferential direction between the gudgeon pin bosses D. As will be seen the edge of the lip E is spaced from the underside of the piston crown so as to provide a slot through which oil delivered in jets from the end of the connecting rod can pass into the trough and through which surplus oil can pass out of the chamber F thus formed between the trough and the crown and out through the open end of the skirt. One or more passages G may be provided leading from the base of the trough to the bearing surfaces of the gudgeon pin bosses and closed at their lower ends by plugs G^1 to assist lubrication of the gudgeon pin.

It will thus be seen that during operation, oil delivered in a jet or jets from the connecting rod enters and accumulates in the chamber between the trough and crown and is continually shaken up and down in that chamber thus taking heat from the part of the skirt and the walls D^1 over which it washes, surplus oil being ejected through the slot between the lip E and the crown. At the same time some of the oil which is trapped in the chamber F may flow away by the passages G leading from the bottom of the trough and thus to the bearing surfaces of the gudgeon pin bosses D, the inertia forces acting on the oil in the trough chamber tending to assist this flow. The bulk of the oil however, will ultimately find its way out of the trough F over the lip E and so escape through the open end of the skirt. The arrangement is preferably such that oil will remain in the chamber F long enough to pick up the maximum heat from the wall B^2 without obtaining too high a temperature. In order to prevent oil which escapes over the lip E from flooding oil drain passages B^3 from upper and lower scraper rings in grooves B^4, the wall C may be provided with a substantially cylindrical skirt-like projection C^1 extending towards the open end of the skirt around the end of the connecting rod. This skirt-like part C^1 which is thus dependent from the flange C tends to cause the oil escaping from the chamber F over the lip E to flow down the outside of the connecting rod to the crank case.

In the construction shown in Figures 1 to 4 the lip E is formed integral with the wall C which itself is integral with the skirt E of the piston. In some cases however, the lip may be constituted by a separately constructed piece which is suitably connected to the inwardly directed wall. Such a construction is shown in Figures 5 and 6, in which an inwardly extending wall C^2 constituting the base of a trough has a plain edge having attached to it a tubular member comprising a part E^1 and a part E^2 extending in opposite directions from a flange E^3. This tubular member is attached to the inner edge of the wall C^2 by studs E^4 passing through the flange E^3, so that the part E^1 functions as the lip of the trough while the part E^2 functions in some degree in the same way as the skirt C^1 in the construction shown in Figure 1. The tubular member E^1 E^2 is conveniently oval in cross-section as can be seen in Figure 6, but in some cases, it may be circular and when so formed, it may be connected to the wall C^2 by screw-threading the exterior of the tubular member and the inner edge of the wall C^2. The tubular member may then have an external rib somewhat similar to the rib E^3 which will determine its position in the axial direction when screwed into the flange C^2. The length of the tubular member E^1 E^2 may vary in accordance with other details in the construction.

Referring to the construction shown in Figures 7, 8 and 9, the crown A of the piston has formed on its under side an annular projection A^1 which extends for

a suitable distance in the axial direction towards the edge of the lip E which in this case, as in the construction shown in Figure 1, is formed integral with the wall C. The lip E is here shown for example, as being somewhat conical as distinct from the cylindrical form in Figure 1. The projection A^1 forms an inverted annular trough or recess A^2 in the marginal part of the underside of the crown and behind one or more of the rings which lie in the grooves B^1, this trough A^2 facing the trough F constituted by the flange C and lip E. The chamber into which the oil is thrown and wherein it is shaken by reciprocation of the piston, is thus constituted by the opposed troughs F and A^2 with the entry slot F^1 into this chamber. As in the construction shown in Figures 1, 2 and 3, the chamber is divided into two similar portions by strengthening walls D^2 which extend between the gudgeon pin bosses D and the crown A of the piston.

The lip E, as also the projection A^1 may both merge into the strengthening walls D^2.

In this construction, oil delivered through a passage H in the connecting rod J passes the gudgeon pin K and through a passage H^1 in a projection J^1 will pass through the slot F^1 into the chamber F and be there shaken between the opposed troughs F and A^2 and in this way, will be at least mainly kept in this chamber and caused to wash over the inner surface of the skirt B behind the grooves B^1 and over the surface of the walls D^2 and thereby have the desired cooling effect.

In a modification of the construction shown in Figures 7, 8 and 9, shown in Figure 10 instead of the crown A being provided with the projection A^1, the inner face of the crown may be formed with a flatly conical projection A^3 as shown in Figure 10, this formation tending to cause the oil to be thrown laterally from the centre of the crown in the manner indicated by the arrows and thus into the chamber F through the slot F^1.

Alternatively, as shown in Figure 11, the outer face of the piston crown may be recessed as at A^4 and as in certain known forms of piston, the whole centre portion of the crown then having a somewhat cup-shape and projecting inwardly. This formation provides within the piston an annular projecting wall A^5 which will form a trough A^6 similar to the trough A^2 in the construction shown in Figure 8, and a conical face A^7 corresponding in function to the surface A^3 in the construction shown in Figure 10, thus causing the oil from the connecting rod to tend to flow into the chamber constituted by the opposed troughs F and A^6 through the slot F^1.

Where the under surface of the crown A is formed with a conical or like curvature extending from a centrally positioned cusp as shown in Figure 10 or Figure 11, this cusp may be located either centrally or at one side of the piston axis. This latter formation will then tend to direct more oil into one of the two sections of the trough than into the other section. With such an arrangement, additional cooling will be provided for the parts in contact with which most of the oil is caused to flow, and this arrangement may be particularly suitable in a piston of known form for use in an internal combustion engine, this piston having a laterally placed recess in the face of the crown as indicated at L in Figure 4, into which fuel is directed.

In some cases, there may be provided in the trough chamber additional walls M as indicated for example in Figures 1, 2, 5, 10 and 12 which project inwardly from the wall B of the piston skirt and extend between the crown and the trough. These walls not only strengthen the piston but will increase the heat dissipating area over which the oil washes as it is shaken to and fro in the chamber F. The walls M in the construction shown do not extend completely across the trough F in the radial direction, but only project a short distance from the wall B of the piston so that they do not interfere with the circumferential continuity of the trough F.

In a piston construction as described above, any given portion of the oil projected by the oil jet or jets into the trough F will tend to be retained there long enough to take up by reason of its rapid washing back and forth over considerable areas of wall surface, considerably more heat than can be picked up by a corresponding quantity of oil either merely projected as a jet against the inside of a piston crown and then allowed to flow away or merely circulated through a substantially closed chamber maintained substantially full of oil within the piston.

Thus during the rapid movement of the oil back and forth between the trough and the piston crown it will flow at considerable speed along the inner surface of the piston skirt and the surfaces of the strengthening walls extending between the crown and the trough thereby promoting the cooling of the skirt both by extracting heat from it direct and reduc-

ing the heat transferred to it from the crown.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A trunk piston comprising a crown from which projects a skirt portion carrying the gudgeon pin bosses wherein a circumferentially extending trough is formed within the piston at a point displaced from the crown comprising a wall which extends inwards from the inner circumferential surface of the skirt portion and a lip portion which extends towards the crown from the inner edge of this wall and leaves between the crown and the lip a slot through which oil delivered in one or more jets from the connecting rod can enter the trough and through which surplus oil leaves the trough and escapes through the open end of the skirt, and two or more walls extend in a generally axial direction between the crown and the trough so that the oil thrown back and forth between the crown and trough due to the reciprocating movement of the piston not only washes over the inner surface of the skirt portion between the crown and the trough but also over the surfaces of the axially extending walls whereby these walls act not only to increase the mechanical strength of the piston but also to carry heat from the crown and transfer it to the oil thrown back and forth between the trough and the crown.

2. A trunk piston comprising a crown from which projects a skirt portion carrying the gudgeon pin bosses, wherein a circumferentially extending trough is formed within the piston at a point displaced from the crown comprising a wall which extends inwards from the inner circumferential surface of the skirt portion and a lip portion which extends towards the crown and the inner edge of this wall and leaves between the crown and the lip a slot through which oil delivered in one or more jets from the connecting rod can enter the trough and through which surplus oil leaves the trough and escapes through the open end of the skirt, the trough comprising two or more circumferential sections separated or partially separated from one another by two or more walls which extend axially from the crown to the trough so that the oil thrown back and forth between the crown and the trough due to the reciprocating movement of the piston not only washes over the inner surface of the skirt portion but also over the surfaces of the walls whereby the walls not only act to increase the mechanical strength of the piston but also to carry heat from the crown and transfer it to the oil thrown back and forth between the trough and the crown.

3. A trunk piston as claimed in Claim 1 or Claim 2, in which the walls comprise or include two walls each extending from one of the gudgeon pin bosses to the crown of the piston so that in addition to their function in carrying heat from the crown to the oil they act as strengthening struts between the crown and the gudgeon pin bosses.

4. A piston as claimed in Claim 3, in which the trough is divided into two circumferential sections by the gudgeon pin bosses and the walls extending therefrom to the piston crown, such sections having no communication with one another except through the slots by which the oil enters and leaves them.

5. A piston as claimed in Claim 3, or Claim 4, in which, in addition to the walls extending from the gudgeon pin bosses to the piston crown there are provided a series of circumferentially spaced walls extending from the crown to the trough but only partially across the trough so as not to divide it completely into further separate circumferential sections.

6. A trunk piston as claimed in any one of the preceding claims, in which a substantially cylindrical skirt-like projection extends from the inner edge of the base of the trough towards the open end of the piston around the end of the connecting rod.

7. A trunk piston as claimed in Claim 1 or Claim 2 or Claim 3 or Claim 4 or Claim 5, in which the lip portion of the trough is formed separately from the base of the trough and is secured thereto.

8. A trunk piston as claimed in Claim 6, in which the lip portion of the trough and the cylindrical skirt-like projection are formed as a separate unit from and attached to the inner edge of the base of the trough.

9. A trunk piston as claimed in Claim 1 or Claim 2 or Claim 3 or Claim 4 or Claim 5 or Claim 7, in which an annular projection is provided on the underside of the piston crown forming an annular trough-like recess between it and the adjacent part of the skirt, which annular recess lies substantially opposite to the trough so as to tend to receive oil thrown up from the trough and to cause such oil to return to the trough during the reciprocating movement of the piston.

10. A trunk piston as claimed in Claim

1 or Claim 2 or Claim 3 or Claim 4, in which the crown of the piston is cupped inwardly so as to form on the inner side of the crown an annular recess lying substantially opposite to the trough so as to tend to receive oil thrown up from the the trough and to cause such oil to return to the trough during the reciprocating movement of the piston.

11. A trunk piston as herein described with reference to Figures 1, 2, 3 and 4, or Figures 5 and 6, or Figures 7, 8 and 9, or Figure 11 of the accompanying drawings.

Dated this 7th day of August, 1947.
KILBURN & STRODE,
Agents for the Applicants.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies, price 2s. 0d. each (inland) 2s. 1d. (abroad) may be obtained.

[This Drawing is a reproduction of the Original on a reduced scale.]

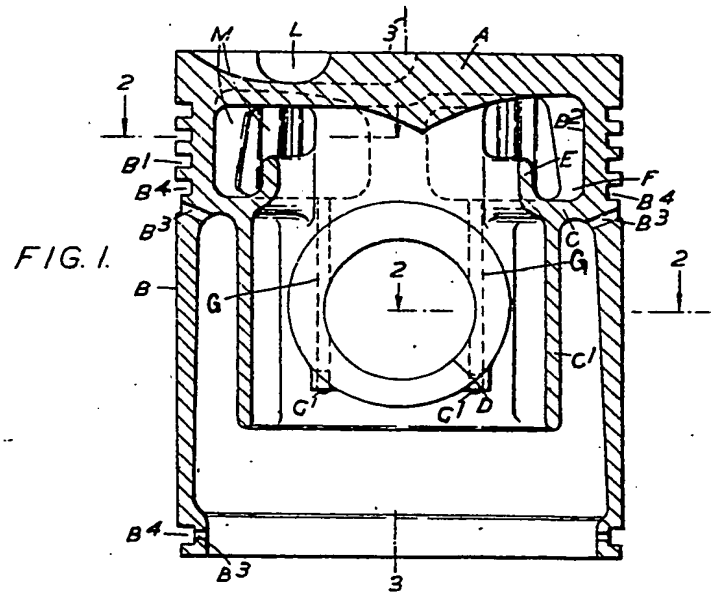


FIG. 1.

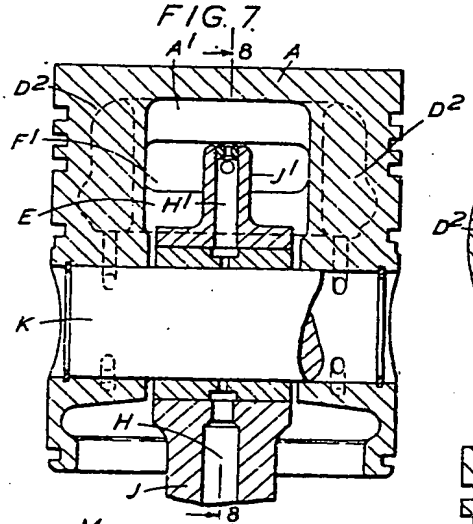


FIG. 7.

FIG. 10.

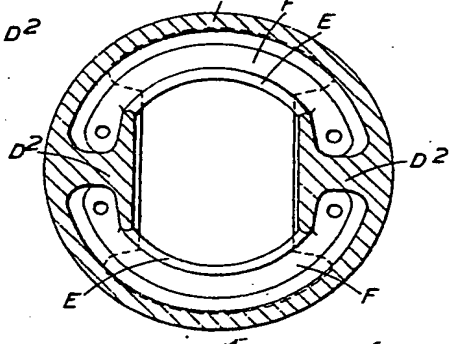


FIG. 9.

FIG. 11.

FIG. 2.

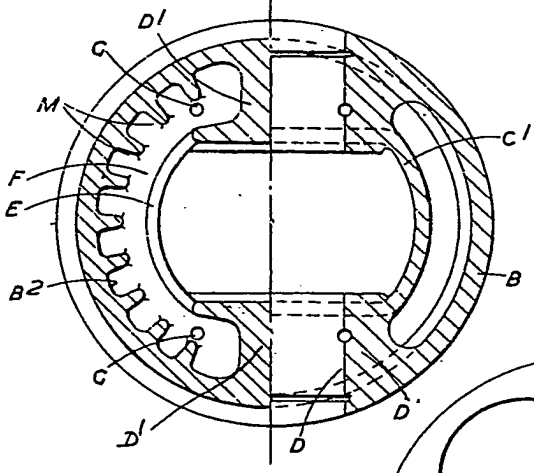


FIG. 4.

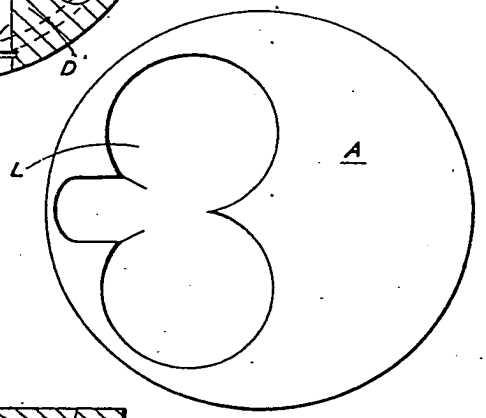
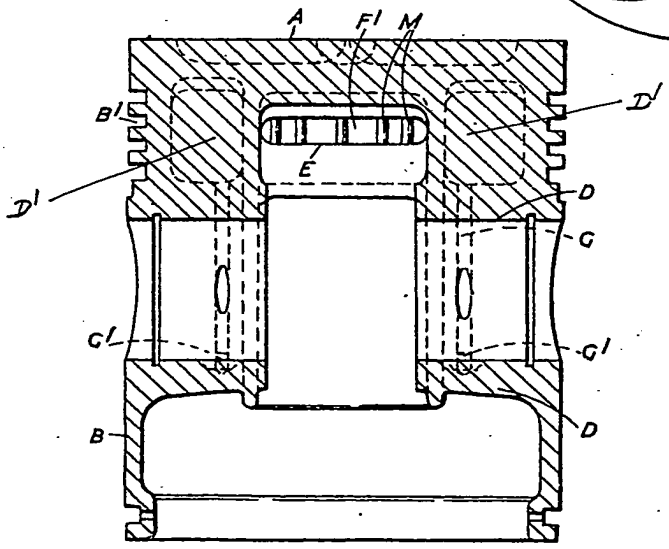


FIG. 3.



617,224 COMPLETE SPECIFICATION

4 SHEETS

SHEET 1

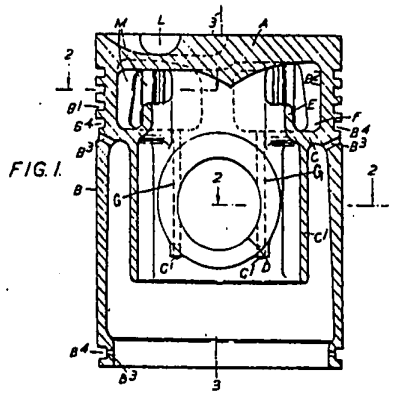


FIG. 1.

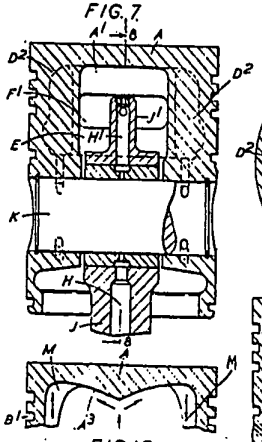


FIG. 10

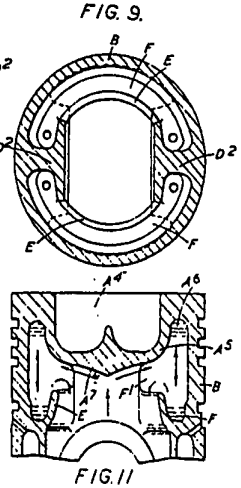


FIG. 11

FIG. 7.

FIG. 9.

SHEET 2

FIG. 2.

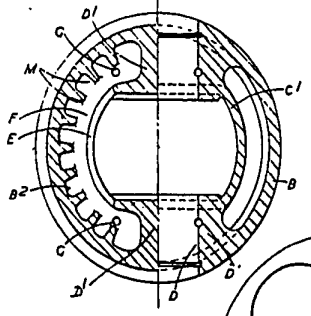


FIG. 4.

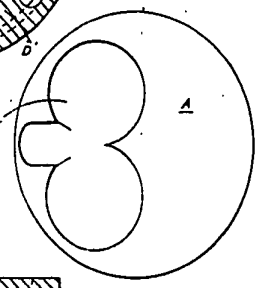
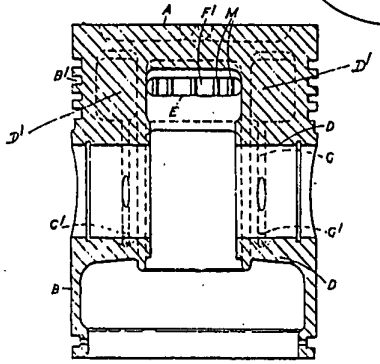


FIG. 3.



[This Drawing is a reproduction of the Original on a reduced scale.]

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FIG. 5.

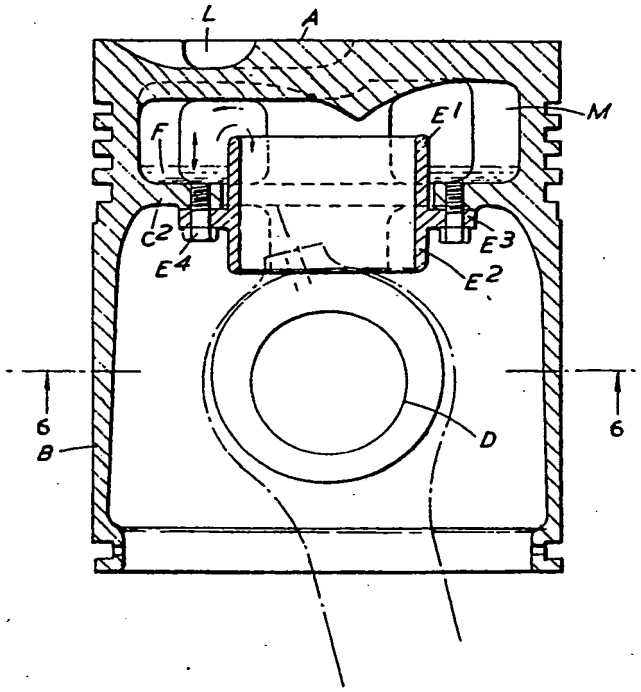

FIG. 6.

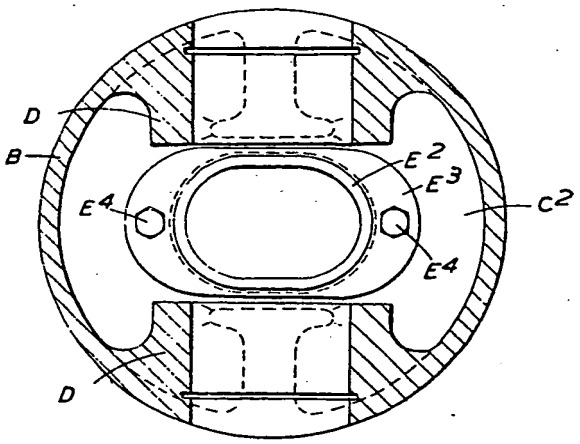

FIG.8.

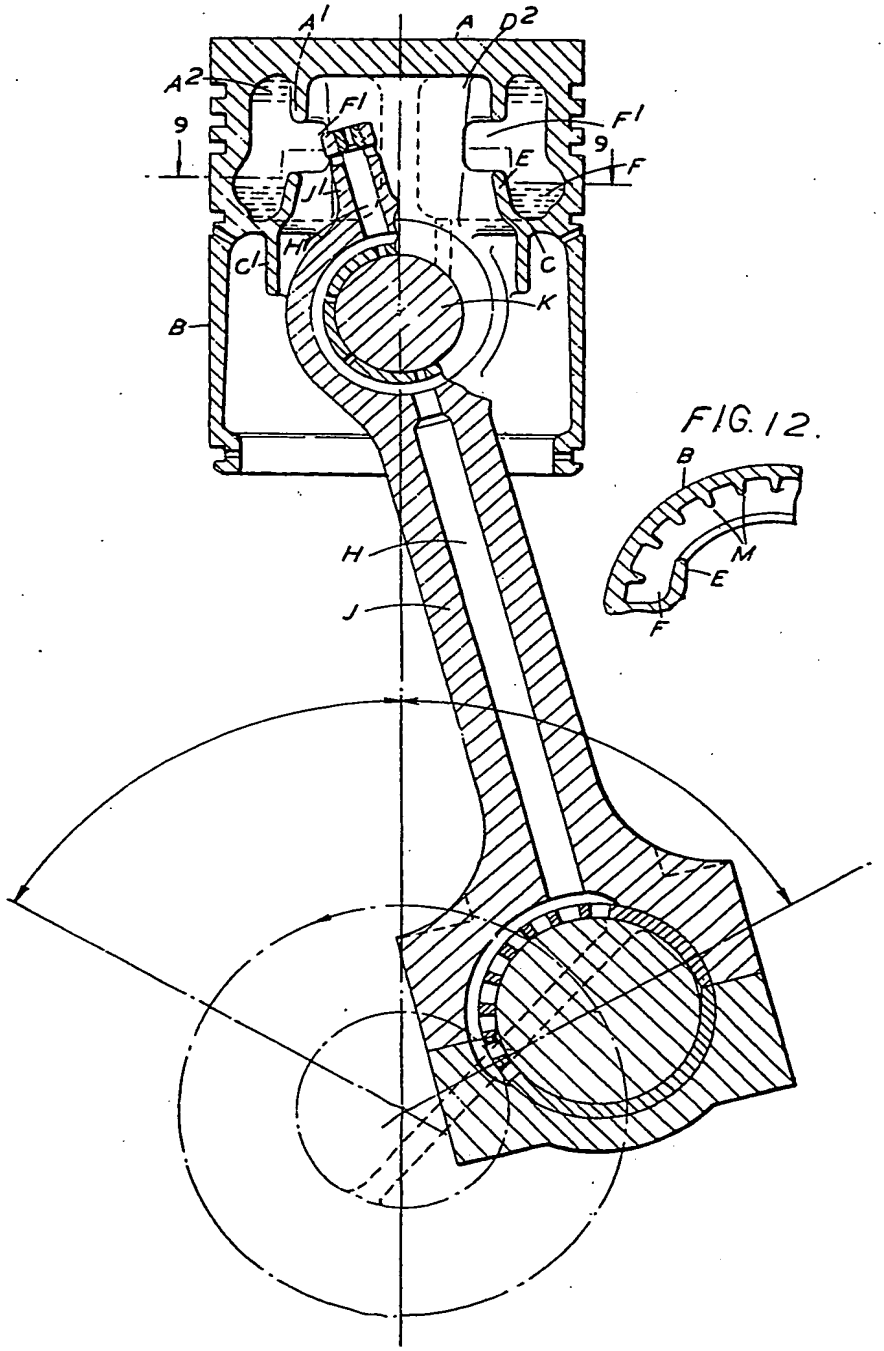

FIG. 12.

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4 SHEETS

SHEET 3

FIG. 5.

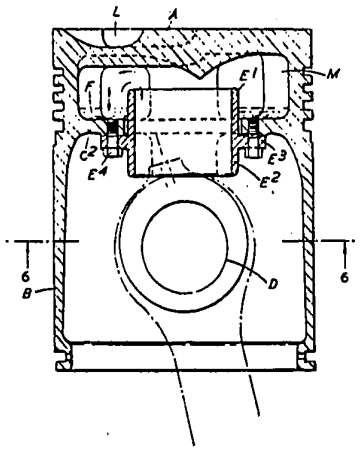
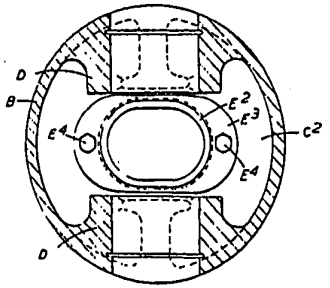


FIG. 6.



SHEET 4

FIG. 8.

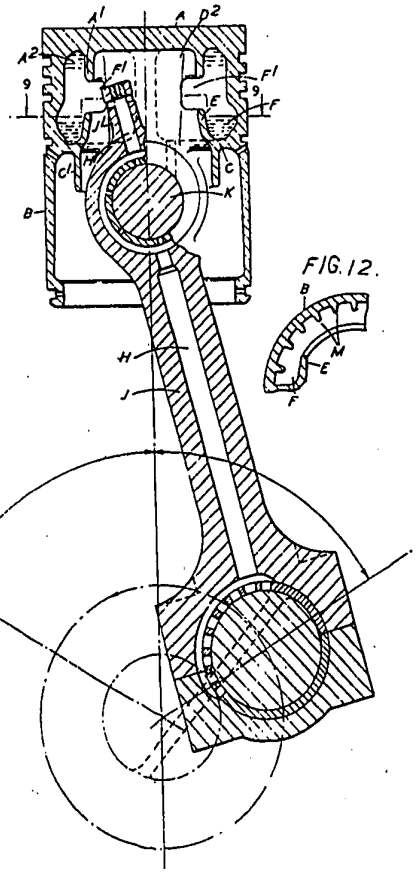


FIG. 12.

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